Chapter 6

Biological Monitoring

- Level 1 Volunteer Water Quality Monitoring Training Notebook -

Macroinvertebrates are good indicators of water quality conditions due to their varying tolerances to pollution. The water quality rating that you determine from your *Macroinvertebrate Data Sheet* will provide a general indication of the water quality in your watershed. **To ensure you have a complete picture of what lives in your stream, three net sets of invertebrates need to be collected from three different microhabitats** (see below). These could include changes in rock size, leaf packs, emergent vegetation, changes in discharge, etc. Collecting invertebrate samples from three different microhabitats is more representative of stream health than sampling one or two habitats. Many invertebrates require a specific type of habitat and sampling three microhabitat types will raise the water quality rating and provide the most complete picture of stream health

Riffles

Stable riffles are excellent places to sample for invertebrates. The habitat of a riffle can be broken down into **microhabitats.** The measurable change in habitat within a riffle may be subtle but present from the upstream to downstream ends, and from side to side. Flow, rock size, leaf packs and algae provide various types of riffle microhabitats. In Ozark streams, finding riffles to sample is not a challenge. In northern and western Missouri prairie streams, however, there are very few riffles to sample. The lack of riffles in Missouri's prairie streams is natural. Therefore, other types of habitat will need to be sampled for invertebrates.

Root Mats

Root mats are the matted roots of vegetation growing from the bank which hang in the water or are growing out of the bank. Root mats are usually found in slower areas of the stream such as runs or pools. This is excellent habitat and is home to many species of dragonflies, damselflies, mayflies and caddisflies. Adequate sampling of root mats requires two people. Have one person place the kick net against the bank on the downstream side of the root mat. Make sure that the net is anchored to the bottom. The other person will then

kick the root mat in a swirling motion with one foot to create a circular current in order to dislodge the invertebrates from the mat. The circular motion of the sampler's foot will wash the invertebrates into the net, even if there is no current.

Woody Debris ("Snags")

Woody debris are special habitats that are home to many mayflies, caddisflies and "true flies" (wormlike larva such as crane flies, midges and black flies). Woody debris are pieces of wood such as tree limbs, logs and sticks that have fallen into the water. Be sure to sample woody debris that has been in the water for some time. The best woody debris to sample has been described as "worm wood." These are pieces of wood that have been in the water long enough that the wood is half rotten and provide many places for invertebrates to live. Sampling woody debris requires two people. Have one person hold the net in a horizontal position about 6 - 12 inches under the water's surface. The second volunteer should remove the woody debris from the water. When removing woody debris from the water, do so quickly. Invertebrates may swim off if the wood is removed too slowly. Brush the debris down with a large brush while holding the net underwater to catch the dislodged invertebrates.

Non-Flow

Non-flow areas of the stream are not in the main channel and do not have flow. These may be pooled areas in pockets behind logs, on the downstream end of a riffle or in a bend in the stream. These are generally depositional areas and have a high amount of organic matter, such as leaves and woody debris, present in them. Sample non-flow areas in the same manner as riffles and collect three separate samples. However, the sampler will need to use a swirling motion with the foot to create a current to move debris into the net. Although this habitat can be sampled with a kick net, it is easier with a D-frame net.

Aquatic Faunal Regions

Ozarks

With the exception of the Bootheel and a few western counties, Ozark streams comprise most of the streams in the southern portion of the state. The gradient of Ozark streams is generally steep, which results in an abundance of riffles.

Streams in the Ozarks are characterized by a riffle-run-pool sequence. The banks of these streams are gently sloping and tend to be a mixture of vegetation and gravel. The stream substrate, or bottom type, is composed of gravel, cobble and sand. Many of the invertebrates sampled in this habitat are adapted to live in the spaces between pieces of gravel or cobble (called "interstitial" spaces) and often attach to the substrate itself.

Glaciated and Osage Prairie Region

Streams Prairie streams comprise most of the streams in northern Missouri and parts of western and southwestern Missouri. They are substantially different from Ozark streams. Prairie streams are slow moving and have very few riffles. They are characterized by the sequence, pool-run-pool. The substrate is generally sand, silt, shelf bedrock and shale. This type of substrate does not provide much in the way of interstitial spaces for invertebrates to inhabit. Therefore, you have to look for types of habitat to sample other than riffles, like root mats, snags and non-flow areas.

Lowland "Streams"

The "Bootheel's" former wetlands have been mostly replaced by agricultural land, now drained by a series of "ditches." The substrate in the faster moving waters is mostly sand and gravel, while slower waters are silt-bottomed. In most cases, ditches can be sampled the same way as prairie streams.

Remember to always collect three net sets from three different microhabitats to determine a water quality rating (one net set at each different microhabitat). Whatever you decide to sample at your site (e.g., two riffle net sets and one root mat, three riffle sets, etc.), always sample those same three microhabitats at the site every time you sample there. This will ensure that the data you collect remains consistent over time. This is extremely important.

Conduct biological monitoring at your site at least two times a year. Once in autumn before leaf fall and once in the late winter or early spring after snow melt (February, March or April). DO NOT sample any one site more than four times per year or you may negatively impact the invertebrates through your sampling.

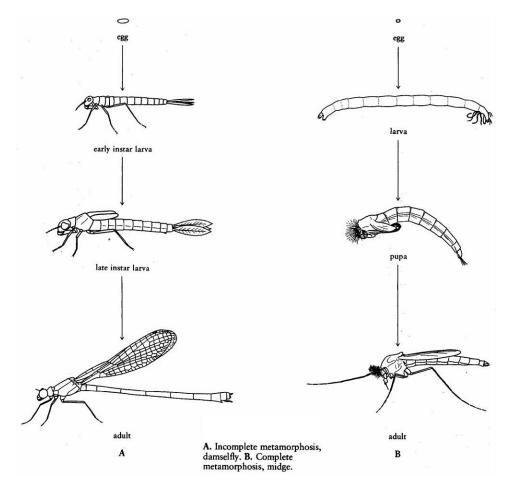
Reference the Biological Monitoring chapter in your *Introduction to Volunteer Water Quality Monitoring* training notebook for more guidance, especially on sampling techniques.

Macroinvertebrate Life Cycles

Aquatic invertebrates spend as much as 99% of their lives in the water while in the larval stage. Since their life cycle may be one to three years, they are excellent indicators of water quality. The adult stage of aquatic invertebrates is often very brief. The primary function of the adult is to mate and lay eggs. Some adults have no functional mouth parts and may only live a few hours. For this reason, the adults are not good water quality indicators. Their life cycles, however, are beneficial to know.

Macroinvertebrate Metamorphosis

Incomplete Metamorphosis	Complete Metamorphosis
Ephemeroptera (Mayfly)	Coleoptera (Beetles)
Hemiptera (Backswimmer)	Diptera (Crane Fly, Midge Fly, Black Fly)
Odonata (Dragonfly, Damselfly)	Lepidoptera (Aquatic Caterpillars)
Plecoptera (Stonefly)	Megaloptera (Hellgrammite, Fishfly, Alderfly)
	Neuroptera (Spongillafly)
	Trichoptera (Caddisfly)



From: Aquatic Entomology: The Fishermen's and Ecologist's Illustrated Guide to Insects and Their Relatives. 1998. W. Patrick McCafferty. Jones and Bartlett Publishers, 40 Tall Pine Drive, Sudbury, MA 01776.

Invertebrate Morphology

The *morph* of an organism refers to its body structure. Therefore, morphology is the study of the structure of the organism. In order to correctly identify macroinvertebrates you will need to be familiar with their morphology. The following is a list of characteristics that are used to identify the different orders of invertebrates found on the *Macroinvertebrate Data Sheet*.

Note that the difference between "nymph" and "larva" concerns the life cycle of the organism. Organisms that undergo complete metamorphosis are called larvae and have a pupa stage in their life cycle. Organisms that undergo incomplete metamorphosis are called nymphs and lack the pupa stage in their life cycle. Note, however, there is some inconsistency in the literature regarding the assignment of the terms "nymph" and "larva."

Key Identification Characteristics

Pollution Sensitive Organisms - Group One Taxa

Stonefly nymph - (Order Plecoptera) $\frac{1}{2}$ "; Sometimes have hair-like

gills under the legs on the thorax (hairy armpits); two tails. Two sets of wing pads on thorax. There are no gills on the

abdomen.

<u>Caddisfly larva</u> - (Order Trichoptera) Up to 1"; Body longer than it is wide;

distinct head; one to three hard plates on thorax; six legs; abdomen ends in two terminal hooks and, unlike thorax,

has no hardened outer plates.

<u>Water penny larva</u> - (Order Coleoptera) ¹/₄"; An immature Water Penny beetle;

flat, saucer-shaped body like a tiny penny; segmented with

six tiny legs underneath.

Riffle beetle - (Order Coleoptera) Adult: a tiny beetle, no longer than 1/4";

dark in color; six legs; crawls slowly on the bottom. <u>Larva</u>: also no longer than ¹/₄"; entire length of body covered with hard plates; six legs on thorax; uniform brown color. *Combine numbers of adults and larvae when reporting*

numbers on data sheets.

Mayfly nymph - (Order Ephemeroptera) 1/4"- 1"; Moving feathery, or plate-

like gills along sides of abdomen; 6 large legs each ending in one hook; 2 to 3 hair-like tails (usually 3); tails may be

webbed together. One set of wingpads on thorax.

Gilled snail - (Class Gastropoda) When holding the snail in your hand

with the shell point up towards your fingers and the opening facing you, the shell opens to the right, so is called "right-handed." DO NOT COUNT EMPTY

SHELLS.

<u>Dobsonfly larva</u> - (Hellgrammite – Family Corydalidae) ³/₄" to 4"; dark in

color; short antennae; large, pinching jaws; 6 legs; 8 pairs of feelers on lower half of the body; lateral filaments on abdomen with paired, cotton-like gill tufts along underside of the filaments; 2 tails and 2 pairs of hooks at back end.

Somewhat Pollution Tolerant Organisms – Group Two Taxa

Crayfish -(Order Decapoda) Up to 6"; 10 legs, 2 large claws; 8 walking

legs; resembles a tiny lobster.

(Order Isopoda) 1/4"- 3/4"; Gray, oblong body wider than it is Sowbug -

high; long antennae; more than 6 legs; looks like a "roly

poly."

(Order Amphipoda) 1/4"; white to gray body higher than it is Scud -

wide; body flattened side-to-side; more than 6 legs;

resembles small shrimp; swims sideways.

Alderfly larva -(Family Sialidae) 1"; Resembles small hellgrammite but has

> one long, thin, branched tail at back end (no hooks); tail may resemble the capital letter "A" at the base; no gills tufts

underneath the lateral filaments on abdomen.

(Family Corydalidae) Up to 1 ½"; Also may resemble a Fishfly larva -

> small hellgrammite, but no gills under lateral filaments on abdomen and the body is often reddish-tan in color or with

yellowish streaks.

Damselfly nymph -(Suborder Zygoptera) ½" – 1"; Large eyes; six thin, hooked

legs; three broad oar-shaped tails; body positioned like a tripod when in water; sides of lower body are smooth

(without gills); usually found in habitats with slower current.

Watersnipe fly

larva -

(Family Athericidae (Atherix)) $\frac{1}{4}$ " – 1"; Pale to green in color; conical head; tapered body; many caterpillar-like legs;

two feathery "horns" on end of abdomen.

Crane fly larva -(Suborder Nematocera) 1/3" - 4"; Milky, green, or light

> brown in color; plump caterpillar-like, segmented body; may have enlarged lobe or fleshy, fingerlike extensions at the end

of abdomen.

Other (aquatic)

Larvae of aquatic beetles other than the Riffle Beetle (Order beetle larva -

Coleoptera) $\frac{1}{4}$ " – 1"; A diverse group; six legs on upper half

of body; feelers; antennae; obvious mouthparts.

(Suborder Anisoptera) $\frac{1}{2}$ " – 2"; Abdomen shape may vary Dragonfly nymph -

> from wide oval (may be flattened and look like a leaf) to torpedo-like; large eyes; mask-like lower lip; 6 hooked legs.

Clam/Mussel -(Class Bivalvia) Combine numbers of both clams and

mussels under this category; DO NOT COUNT EMPTY

SHELLS.

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Pollution Tolerant Organisms - Group Three Taxa

Aquatic worm & (Include all wormlike organisms) Class Oligochaeta, ¼"-2": aquatic earthworms with segmented bodies; may look thin or gray. Phylum Nematomorpha (horsehair worms), 4"-27": body not segmented; may look like a coiled horsehair and appear tangled.

Midge fly larva - (Suborder Nematocera) In Missouri streams, usually less than ½"; Wormlike, segmented body; has distinct head; two tiny legs (prolegs) on first segment and also at tip of abdomen.

Black fly larva - (Family Simuliidae) Up to ¼"; One end of body wider than the other; black head; sometimes have fanlike projections on head for filtering; suction pad on tip of abdomen.

<u>Leech</u> - (Order Hirudinea) ½"-2"; Flattened; has sucker mouth; more "muscular" than aquatic worms.

Pouch snail - (Class Gastropoda) No operculum; breath air; when holding the snail in your hand with the shell point up towards your fingers and the opening facing you, **the shell opens to the left, so they are called "left-handed**." DO NOT COUNT EMPTY SHELLS.

Other snail - (Class Gastropoda) Snail shell is flat, coils in one plane and does not have a point. DO NOT COUNT EMPTY SHELLS.



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Illustrations by A.V. Provonsha from W. Patrick McCafferty Aquatic Entomology Jones & Bartlett Publishers, 1983 Used by Permission

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ABOUT THIS KEY

Keys are guides to the identification of plants or animals. Macroinvertebrate keys arrange macroinvertebrates' characteristics in a way that leads you in a logical manner to place the organism in the correct grouping or "taxon" (order or family, for example). Most keys use "couplets" – two mutually exclusive statements regarding a physical characteristic of the organism – and illustrations that highlight the characteristic being examined. The statement which is true for that organism directs the user to subsequent couplets until the organism is placed in a taxon.

This visual key is intended to be used with River Watch Network's "Guide To Macroinvertebrate Sampling" and "Key To The Freshwater Macroinvertebrate Fauna of New England." It is intended to make it easier for people unfamiliar with benthic macroinvertebrates to identify them, before attempting to use a more traditional "couplet" key. This key enables the user to first match the organism to one or more drawings, then see if the organism has the characteristics that would place it in the taxon illustrated by those drawings. In many ways, it's similar to a "field guide" approach.

HOW TO USE THIS KEY

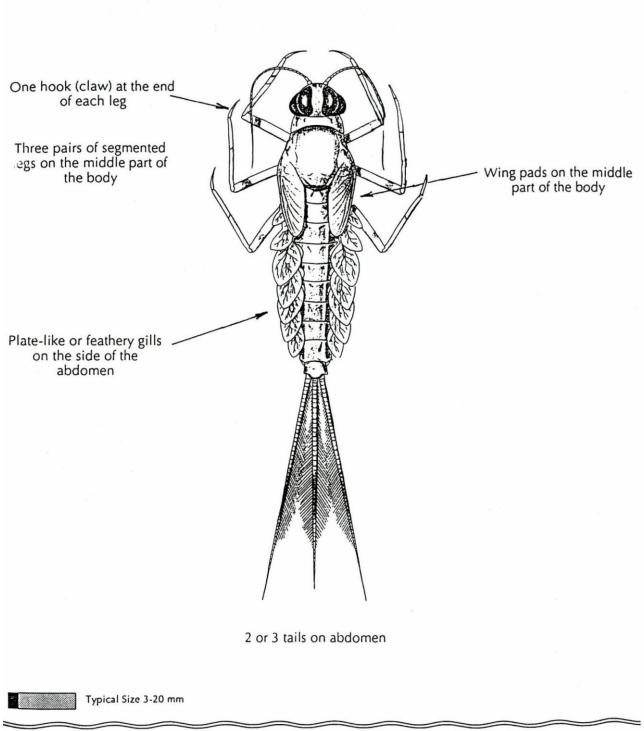
First, find the picture or pictures in the key that most closely resemble the organism you're trying to identify. Then find the page that illustrates the characteristics of the major group that goes with the picture. If the characteristics matcha those of your organism, you've identified the major group. If not, find another page with characteristics that match your organism. If you are still unable to identify the organism, refer to the "Key To The Freshwater Macroinvertebrate Fauna of New England." If you are still not sure about a particular organism, preserve it in a vial of ethanol and have a more experienced person assist you.

To give you an idea of the range in size of each organism, a bar like the one shown below is included. The black part of the bar shows the size of a smaller one. The gray part of the bar shows the range in size above the typical minimum. Next to the bar is the measurement range in millimeters.

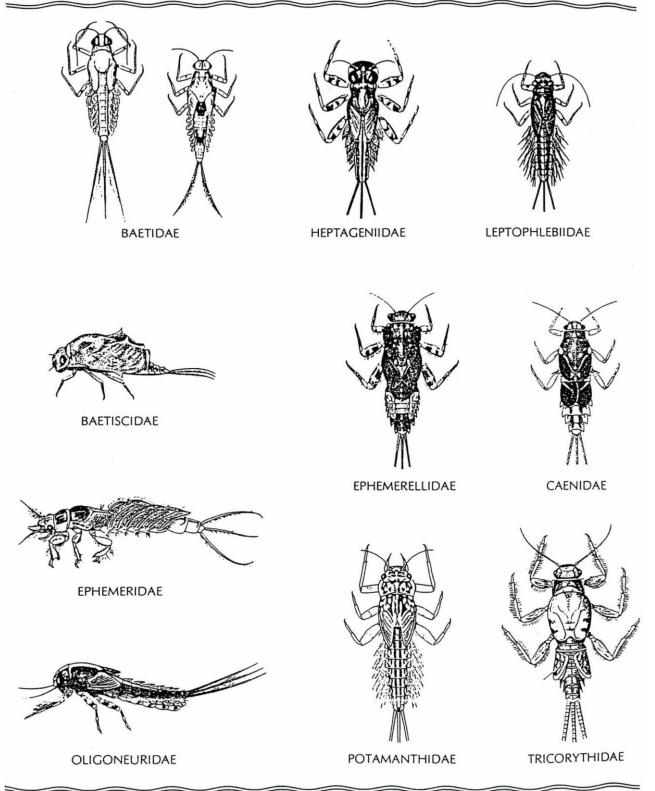
Typical Size 3-20 mm

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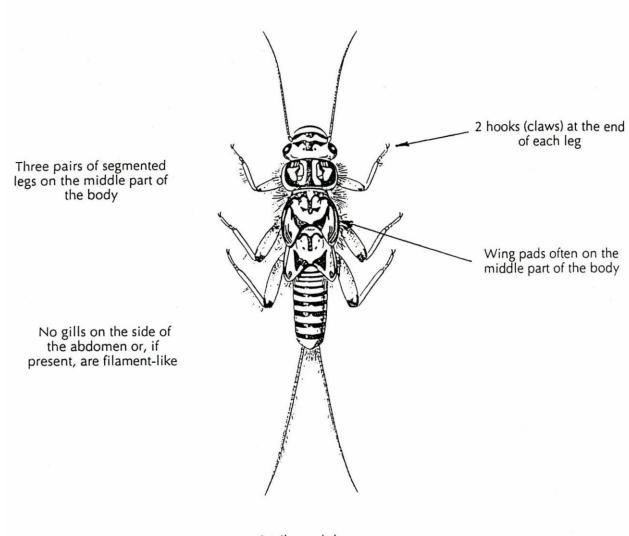
Characteristics of MAYFLIES	2
Examples of Common MAYFLY Families	
Characteristics of STONEFLIES	4
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Characteristics and Examples of OTHER AQUATIC INSECTS	
Characteristics and Examples of OTHER COMMON BENTHIC MACROINVERTEBRATES	
Characteristics and Examples of Common BENTHIC MACROINVERTEBRATE PUPAE	



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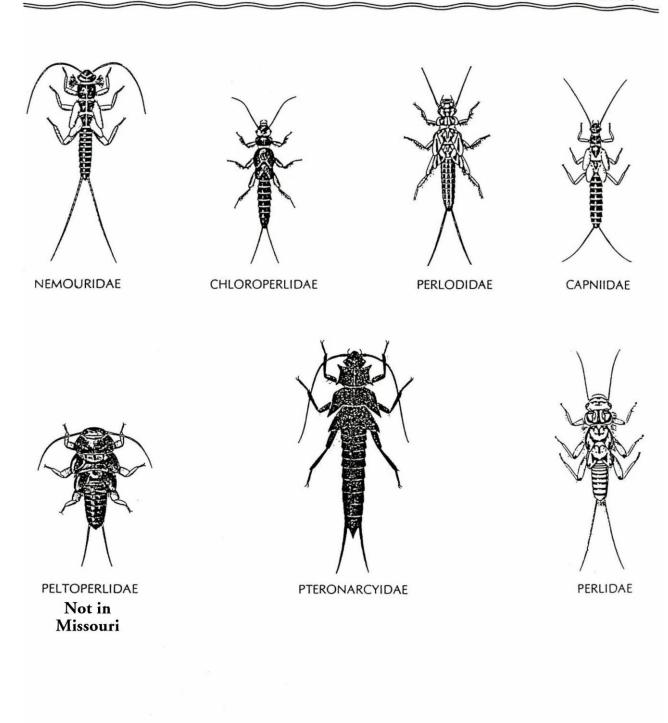


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2 tails on abdomen

Typical Size 5-35 mm



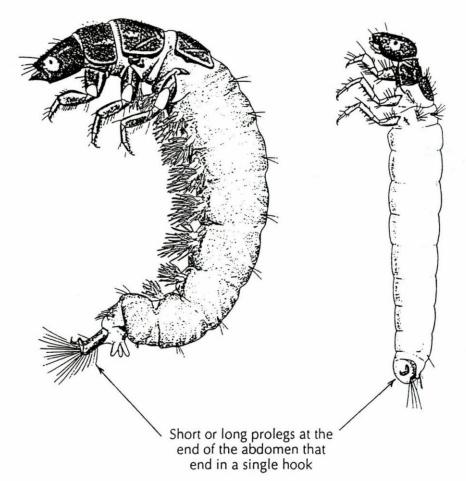
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The insect may be in a case made of sand grains, or bits of leaf or twigs



Three pairs of segmented legs on the middle part of the body

Filament-like gills may be present on the underside of the abdomen



No wing pads on the middle part of the body

Typical Size 2-40 mm

Examples of: Common CADDISFLY Families (Order TRICHOPTERA) In Freshwater Rivers

Netspinners







HYDROPSHYCHIDAE

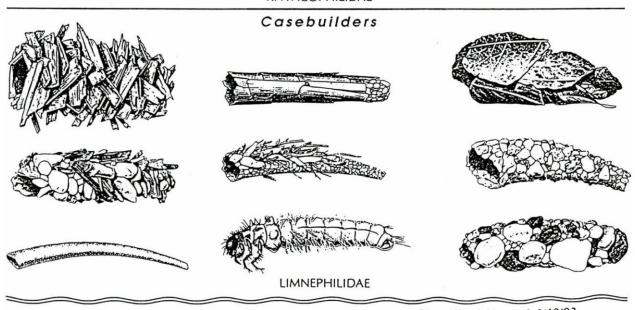
PHILOPOTAMIDAE

POLYCENTRIPODIDAE

Freeliving



RHYACOPHILIDAE



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Examples of: Common CADDISFLY Families (Order TRICHOPTERA) In Freshwater Rivers

Casebuilders













LEPIDOSTOMATIDAE

BRACHYCENTRIDAE







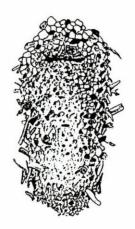




HELICOPSYCHIDAE

ODONTICERIDAE

PHRYGANEIDAE







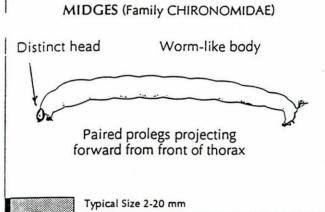


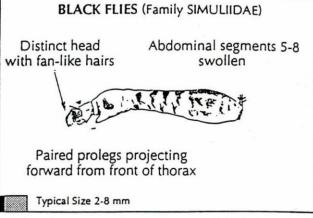
MOLANNIDAE

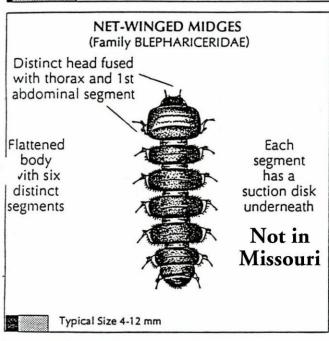
LEPTOCERIDAE

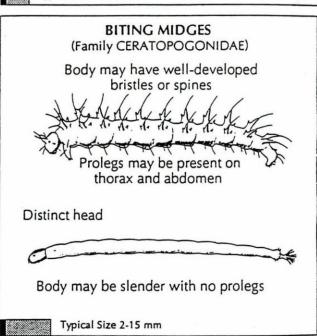
HYDOPTILIDAE

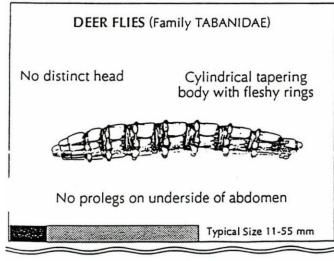
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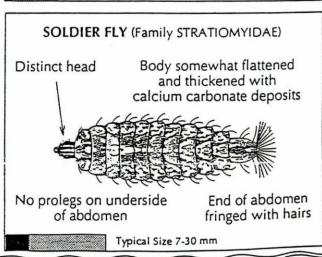












CRANE FLIES (Family TIPULIDAE)

No distinct head. Usually retracted inside body

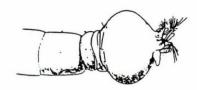
Cylindrical body

Abdomen may be bulbous or end in fleshy projections

Ridges on top of abdomen top of the abdomen Short prolegs

Short prolegs under abdomen

Antocha



Hexatoma



Tipula



Pseudolimnophila

Typical Size 10-100 mm

SNIPE FLIES (Family ATHERICIDAE)

No distinct head

Short filaments on top and side of each abdominal segment Abdomen ends in two pointed projections longer than prolegs



Well-developed prolegs ending in tiny hooks on underside of abdomen

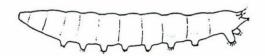
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Typical Size 12-18 mm

DANCE FLIES (Family EMPIDIDAE)

No distinct head

Abdomen ends in one to four rounded projections shorter than prolegs



Usually with well-developed prolegs on underside of abdomen

Typical Size 2-7 mm

RIFFLE BEETLE larva (Family ELMIDAE)

Body elongated



Abdominal segment 9 has a notched chamber with filament-like gills inside and hooks underneath

Typical Size 2 - 10 mm

LONGTOED WATER BEETLE larva (Family DRYOPIDAE)

(no picture) similar to ELMIDAE larvae but no gills in notched chamber

Typical Size 2 - 10 mm

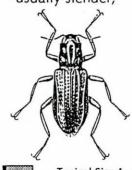
WATER PENNY (Family PSEPHENIDAE)

Body disk-like with plates covering head and legs

Typical Size 2 - 10 mm

RIFFLE BEETLE adult (Family ELMIDAE)

Antennae: - usually slender,



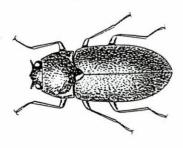
 sometimes short and clubbed



Typical Size 1 - 8 mm

LONGTOED WATER BEETLE adult (Family DRYOPIDAE)

Antennae: always short, never clubbed



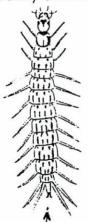
Typical Size 4 - 10 mm

WHIRLIGIG BEETLE (Family GYRINIDAE)

Light-colored

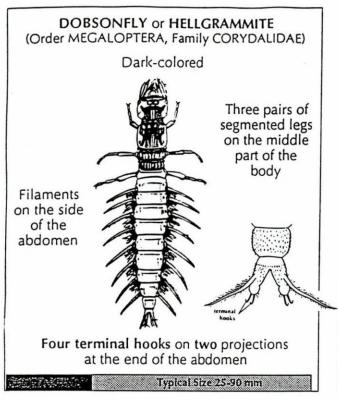
Three pairs of segmented legs on the middle part of the body

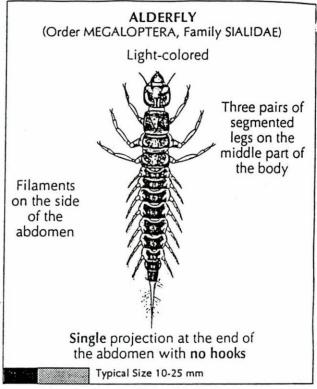
Filaments on the side of the abdomen

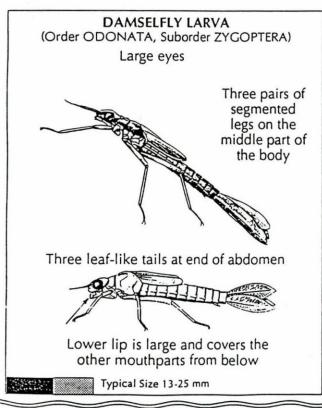


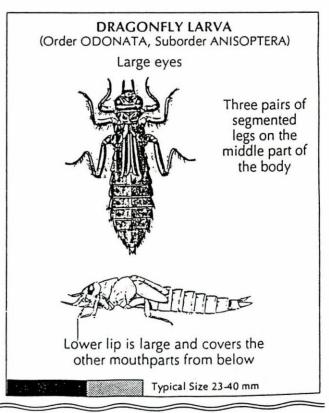
Four terminal hooks on a single projection at the end of the abdomen

Typical Size Up To 30 mm

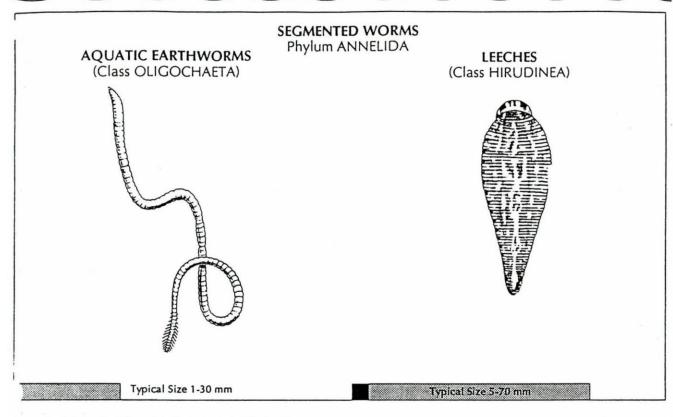


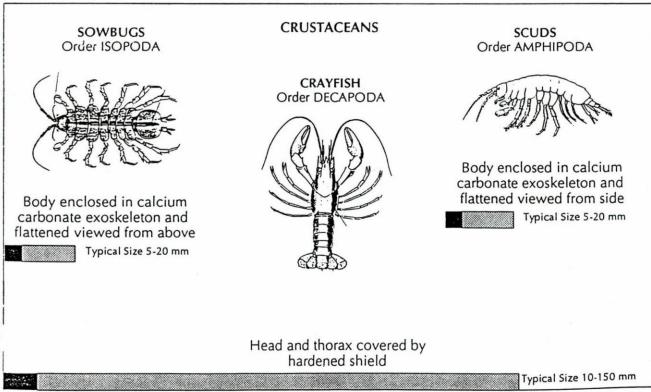


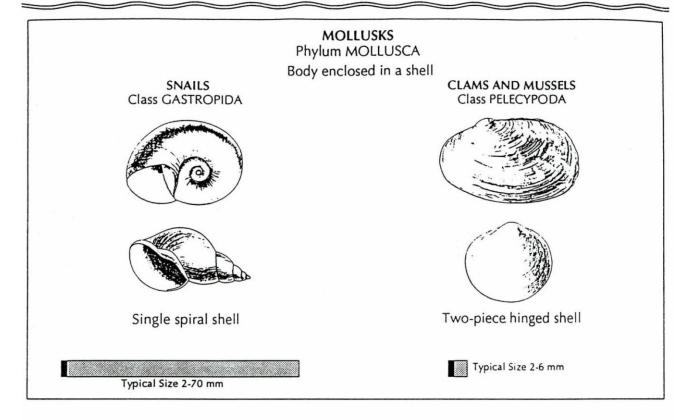


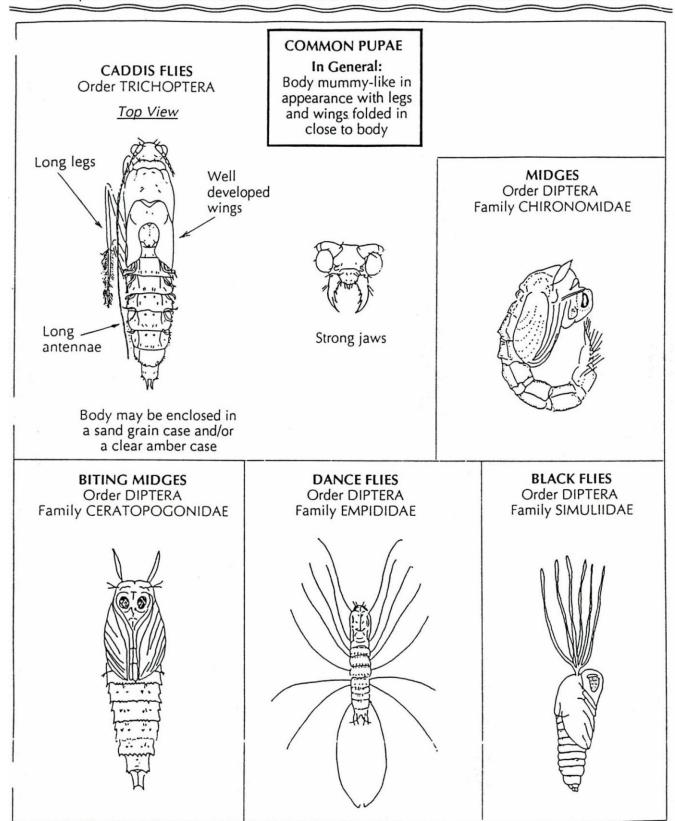


Examples of: OTHER COMMON BENTHIC MACROINVERTEBRATES In Freshwater Rivers









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